The CerOx Process: Electrochemical Process for Organic Hazardous Waste Destruction

Norvell Nelson & Thomas M. Neustedter
CerOx Corporation
2602 Airpark Drive
Santa Maria CA 93458

At the present time, incineration is the generally used method for destruction of organic waste materials generated by industry. The chemistry and physics of incineration processes are such that the production of dioxin type materials is obligatory given the process conditions. The standard "fix" for this open-ended technology has been the addition of more back-end processing such as secondary burners, precipitators, wet scrubbers and baghouse filters. Nevertheless, waste incineration processes continue to mostly operate outside of regulatory specifications.

The CerOx Process operates near room temperature and at atmospheric pressure using an aqueous electrolyte containing nitric acid and cerium(IV) nitrate. The process anolyte destroys organic materials because the Ce(IV) metal ion catalyst is a thermodynamically powerful oxidizer. The highly oxidizing environment of Ce(IV) for organic materials is achieved by direct application of electrical energy rather than thermally with a high temperature flame as in an incineration process.

The CerOx Process is comprised of four distinct chemical reactions/unit operations that are temporally and physically separate. The reactions/ unit operations are: organic destruction by Ce(IV); regeneration of the Ce(IV) oxidant; the cathode reaction, reduction of nitric acid to nitrous acid; and, the recovery of nitric acid from the cathode reduction product. Since the cerium is not consumed in the process it is a catalyst which is electrochemically regenerated.

The CerOx System 4 unit used for the results reported here is located at the University of Nevada in Reno. The CerOx System is used to destroy the University's organic wastes in lieu of transportation of the wastes for off-site disposal. The results of recent test runs performed at the University of Nevada will be reviewed.

The results of the recent test runs will be presented that demonstrate the efficacy of the process to destroy common organic waste materials such as methylene chloride, BTX materials (benzene, toluene and xylene), acetonitrile, ethers, ketones and alcohols. The data include measurements of the residual organic burdens in the exhaust gas stream and scrubber discharge water stream.

In addition, an update on the design and construction of the CerOx proprietary electrochemical cell will be presented. The electrochemical cell is fabricated from mold-injected PVDF and has an all welded construction to eliminate leaks and it forms the cornerstone of the Company's modular design approach for the design and manufacture of it hazardous waste destruction equipment.

The CerOx T-CELL is a monolithic bipolar stack of 10 cell pairs in the series configuration. The electrodes are titanium with a platinum coating on the anode side of each plate. A picture of the CerOx T-CELL is shown in Figure 1. The catholyte and anolyte solutions are separated with a Nafion® membrane. The T-CELL is normally operated at 500A and 26-30V with a current density of about 3800A/m^2.

The CerOx Process equipment is fabricated from either titanium, process tanks, or PVDF, process piping. The System 4 operates under the control of a PLC and is thoroughly instrumented for fully automatic operation. The total operating package for a System 4 is housed in a 6' x 8' chemical storage shed with its own secondary containment. Owing to containment regulations, the organic waste drum and the caustic for the gas scrubber lie outside of the 6' x 8' containment skid.

Figure 1: CerOx PVDF T-CELL

Since the CerOx process is performed in a series of tanks and pipes, the CerOx process is classified by EPA as a tank system. As a tank system, the CerOx Process does not require an EPA RCRA permit (Part B Permit). The process reaction conditions are such that the conditions, e.g., high temperature, needed for the synthesis of dioxins from chlorocarbon feed materials are never obtained making the CerOx process a dioxin destroyer, not a dioxin maker.

The CerOx System 4 has a waste throughput of 1/2 drum per day of waste organic material. Water is easily accommodated since it doesn't consume Ce(IV); its presence does not alter the quantity of the organic waste throughput. Once waste feed is initiated, the rate of feed is automatically controlled by monitoring the level of Ce(IV) in process and adjusting the organic feed rate to match the electrochemical production of the Ce(IV) oxidant.

The CerOx Process offers considerable savings in energy and carbon dioxide emissions compared to hazardous waste incineration. The CerOx process produces considerably less CO_2 compared to standard incineration even including the CO_2 burden from 100% fossil fuel electricity.